HUC 07140101 – Cahokia-Joachim Subbasin
Water bodies: 1709
Pollutant(s): Pathogens as indicated by *Escherichia coli*

MISSOURI NATURAL RESOURCES

WATER PROTECTION PROGRAM

Total Maximum Daily Load (TMDL)

for

Maline Creek

St. Louis County and St. Louis City

Pollutants of concern: Pathogens

Submitted: July 11, 2017

Approved: April 25, 2018

Prepared by: Watershed Protection Section

WATER BODY SUMMARY
Total Maximum Daily Load (TMDL) for Maline Creek
Pollutant: Pathogens as indicated by *E. coli*

Name: Maline Creek


State Map Showing Location of Watershed

Location: St. Louis County and St. Louis City

Nearby City: St. Louis

12-digit Hydrologic Unit Code (HUC) and Name:[1]
071401010401 – Maline Creek-Mississippi River

Water Body Identification Number and Hydrologic Class:[2]
Water body ID No. 1709 – Class C

Designated uses:[3]
Livestock and wildlife protection
Irrigation
Protection and propagation of fish, shellfish and wildlife – warm water habitat
Human health protection
Secondary contact recreation
Whole body contact recreation category B

Uses that are Impaired:
Whole body contact recreation category B

Length and location of impaired segment:
WBID 1709 0.97 km (0.6 mi), from Sur 3125,46N,7E to 9,46N,7E (Land grant 00003)

Universal Transverse Mercator [Zone 15 north] coordinates:
WBID 1709 From E: 741487, N: 4290493 to E: 741068, N: 4291197

Pollutant on 2016 303(d) List:
Escherichia coli, or *E. coli*, bacteria

[1] A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).

[2] For hydrologic classes see 10 CSR 20-7.031(1)(F). Class C streams may cease flow during dry periods, but maintain permanent pools that support aquatic life.

[3] For designated uses see 10 CSR 20-7.031(1)(C) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(E).

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1. Introduction

The Missouri Department of Natural Resources in accordance with Section 303(d) of the federal Clean Water Act is establishing this Maline Creek total maximum daily load, or TMDL. Maline Creek is included on Missouri's 2016 303(d) List of impaired waters. The listing of Maline Creek as impaired by pathogens as indicated by *Escherichia coli*, or *E. coli*, bacteria was approved by the U.S. Environmental Protection Agency on July 12, 2016. The department's 303(d) submittal to EPA cited urban runoff and storm sewers as likely sources of the impairment. This report addresses the Maline Creek pathogen impairment by establishing a TMDL for *E. coli*. Data analyses conducted to support this listing and TMDL development indicate that *E. coli* are present at concentrations that result in exceedances of Missouri's water quality criteria for the protection of whole body contact recreation.

Section 303(d) of the federal Clean Water Act and Chapter 40 of the Code of Federal Regulations (CFR) Part 130 requires states to develop TMDLs for waters not meeting designated uses. The TMDL process quantitatively assesses the impairment factors so that states can establish water quality-based controls to reduce pollution and restore and protect the quality of their water resources. The purpose of a TMDL is to determine the pollutant loading a water body can assimilate without exceeding state water quality standards. Missouri's Water Quality Standards at 10 CSR 20-7.031 consist of three major components: designated uses, water quality criteria to protect those uses and an antidegradation policy. The TMDL establishes the pollutant loading capacity necessary to meet the water quality standards established for each water body based on the relationship between pollutant sources and instream water quality conditions. A TMDL consists of a wasteload allocation, a load allocation, and a margin of safety. The wasteload allocation is the fraction of the total pollutant load apportioned to point sources. The load allocation is the fraction of the total pollutant load apportioned to nonpoint sources. The margin of safety is a percentage of the TMDL that accounts for any uncertainty associated with the model assumptions as well as any data inadequacies.

Maline Creek was first listed as impaired by pathogens in 2012 due to elevated *E. coli* concentrations. Missouri's 2016 listing methodology determines a water to be impaired by bacteria if the geometric mean of measured *E. coli* exceeds the water quality criteria during any of the last three years' recreational seasons in which a minimum of five samples have been collected. Missouri's recreational season extends from April 1 through October 31. Data meeting these listing methodology specifications were collected and do show Maline Creek to be impaired by *E. coli*.

2. Watershed Description

Maline Creek is an urban stream located in eastern Missouri in St. Louis County. Approximately 0.97 kilometers (0.6 miles) of the stream are identified in the Missouri Use Designation Dataset as water body identification number, or WBID, 1709.[4] This segment of Maline Creek begins at Bellefontaine Road and flows east into the City of St. Louis. Maline Creek originates in Berkeley and flows approximately 14.2 km (8.8 mi) before entering the Mississippi River in St. Louis (USGS 2017). Approximately 66 km^2 (25.5 mi^2) drain to segment 1709 of Maline Creek (Figure 1).

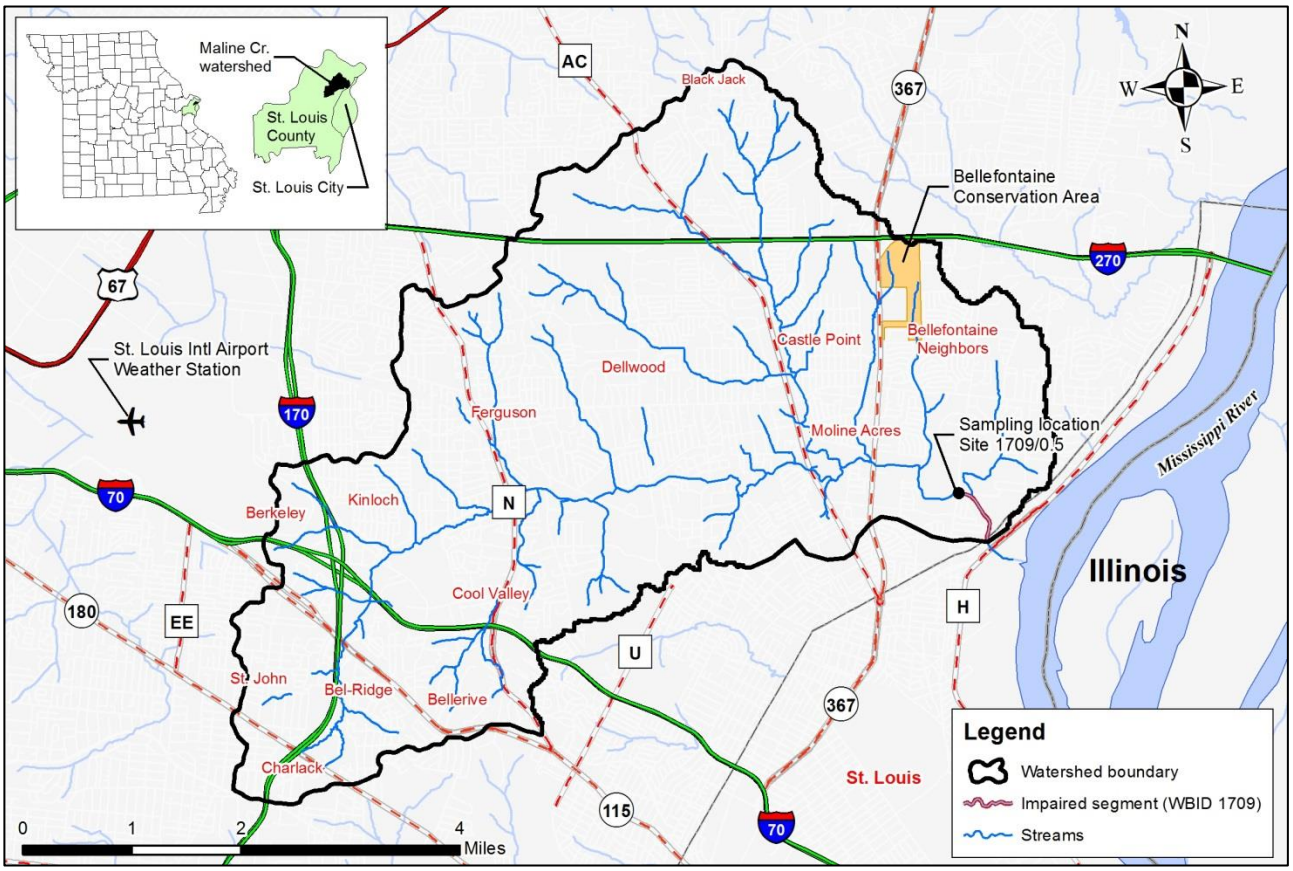

Figure 1. The Maline Creek watershed

[4] The Missouri Use Designation Dataset documents the names and locations of the state's rivers, streams, lakes and reservoirs, which have been assigned designated uses. See 10 CSR 20-7.031 (1)(P).

2.1 Geology, Physiography and Soils

The Maline Creek watershed is a portion of the larger Cahokia-Joachim subbasin, identified by the 8-digit hydrologic unit code, or HUC, 07140101, which in addition to Missouri, lies within portions of Illinois.[5] The Missouri portion of the Cahokia-Joachim subbasin is located within the Apple/Joachim ecological drainage unit (MoRAP 2005). Ecological drainage units are groups of watersheds that have similar biota, geography and climate characteristics (USGS 2009). The characteristics of an ecological drainage unit are varied and are partially based on the ecoregions that are contained within the drainage unit. Ecoregions are areas with similar ecosystems and environmental resources.[6] A level I ecoregion is a coarse, broad category, while a level IV is a more defined grouping. The watershed area for WBID 1709 of Maline Creek is contained entirely within the River Hills ecoregion. This area is a transition zone between the Central Irregular Plains and the Ozark Highlands. Key characteristic features of the River Hills are loess-covered hills and numerous karst features (Chapman et al. 2002). Karst features in the Maline Creek watershed include a single gaining reach on an unnamed tributary to Maline Creek that begins near Florissant and ends in Castle Point (MoDNR 2014).

Soils in the Maline Creek watershed are varied, but can be grouped based on similar characteristics. Table 1 provides a summary of hydrologic soil groups in the Maline Creek watershed. Hydrologic soil groups categorize soils by their runoff potential. A soil's hydrologic soil group relates to the rate at which water enters the soil profile under thoroughly wetted, bare soil surface conditions. Group A represents soils with the highest rate of infiltration and the lowest runoff potential under these conditions and Group D represents the group with the lowest rate of infiltration and highest potential for runoff (NRCS 2007). The dominant soil group in the Maline Creek watershed is Group C. Group C includes sandy clay loam soils that have a moderately fine to fine structure. These soils consist chiefly of soils with a layer that impedes downward movement of water. In some cases, soils are placed in dual soil groups based on both the depth to the water table and the soils ability to drain. In the Maline Creek watershed, more than 11 percent of the watershed area is categorized as having soils in the dual group C/D and has characteristics of Group C and a high water table that is typically found in Group D soils. Approximately 2.7 percent of the watershed area could not be rated in a hydrologic soil group. In the Maline Creek watershed, areas that are not rated include quarries, open water, and areas with the soil type Urban land, upland, 0 to 5 percent slopes. Figure 2 shows the distribution of these hydrologic soil groups throughout the Maline Creek watershed.

[5] Watersheds are delineated by the USGS using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS and NRCS 2013).

[6] Ecoregion is defined in Missouri's Water Quality Standards at 10 CSR 20-7.031 (1)(I).

Table 1. Hydrologic soil groups in the Maline Creek watershed (NRCS 2011)

Soil Group:	***Group C***	***Dual Group C/D***	***Not Rated***	***Total***
Area: km² (mi²)	56.69 (21.89)	7.61 (2.94)	1.81 (0.70)	66.11(25.53)
Percentage: %	85.7	11.5	2.7	100

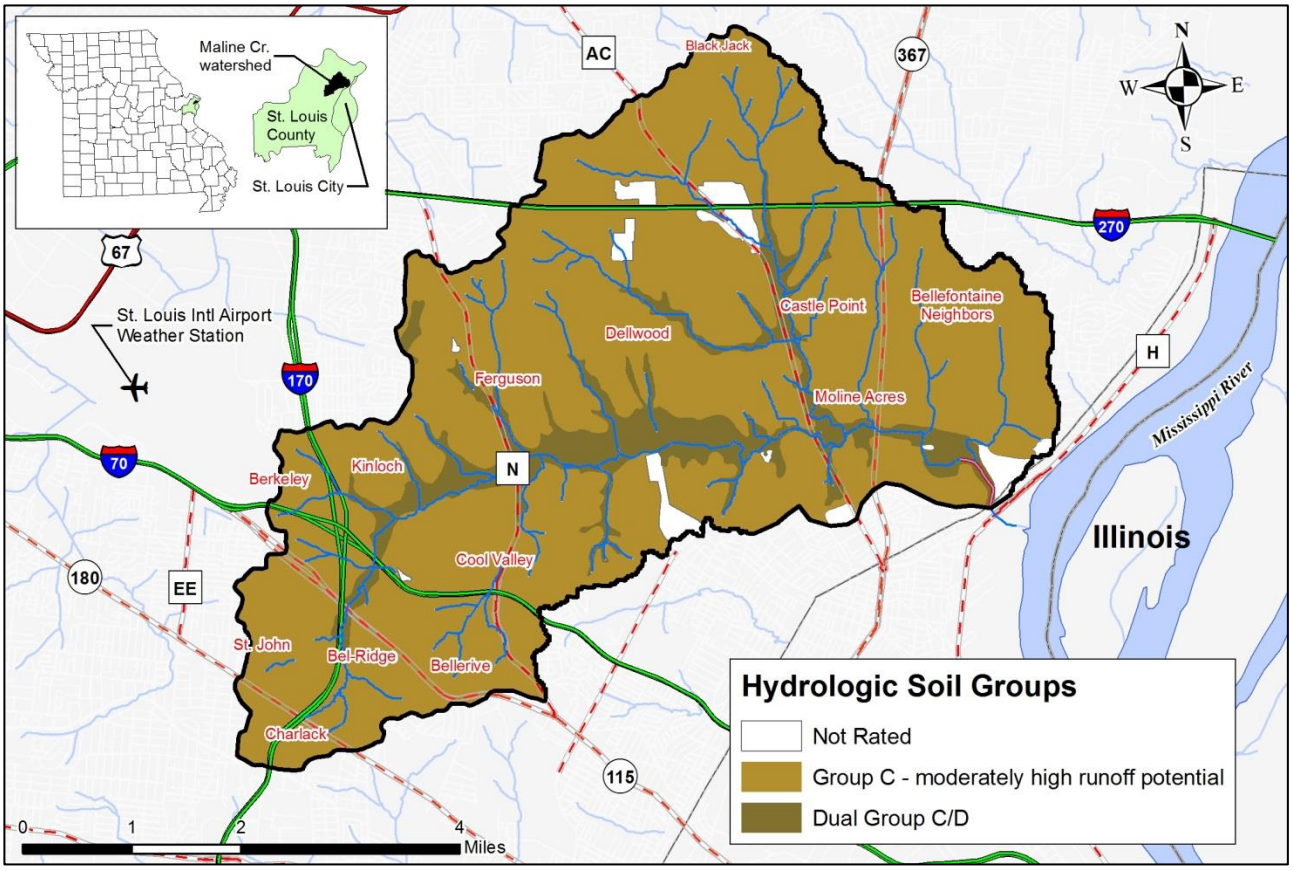

Figure 2. Hydrologic soil groups in the Maline Creek watershed (NRCS 2011)

2.2 Rainfall and Climate

Weather stations provide useful information for developing a general understanding of climatic conditions in a watershed. The Lambert-St. Louis International Airport weather station is the closest source to the Maline Creek watershed with recent and available weather and climate data (Figure 1). This station records daily precipitation, and maximum and minimum temperature data, which are expected to be representative of conditions in the Maline Creek watershed. Precipitation is an important factor for stream flow and runoff events that can influence certain pollutant sources that may contribute bacteria loads. Figure 3 and Table 2 provide annual average precipitation and annual average minimum and maximum temperatures from 1981 through 2010.

Table 2. 30-year climate data from the St. Louis International Airport weather station (NOAA 2011)

Weather Station	***Annual Average Precipitation cm (inches)***	***Annual Average Minimum Temperature °C (°F)***	***Annual Average Maximum Temperature °C (°F)***
Lambert-St. Louis Airport	103.9 (40.92)	8.78 (47.8)	18.94 (66.1)

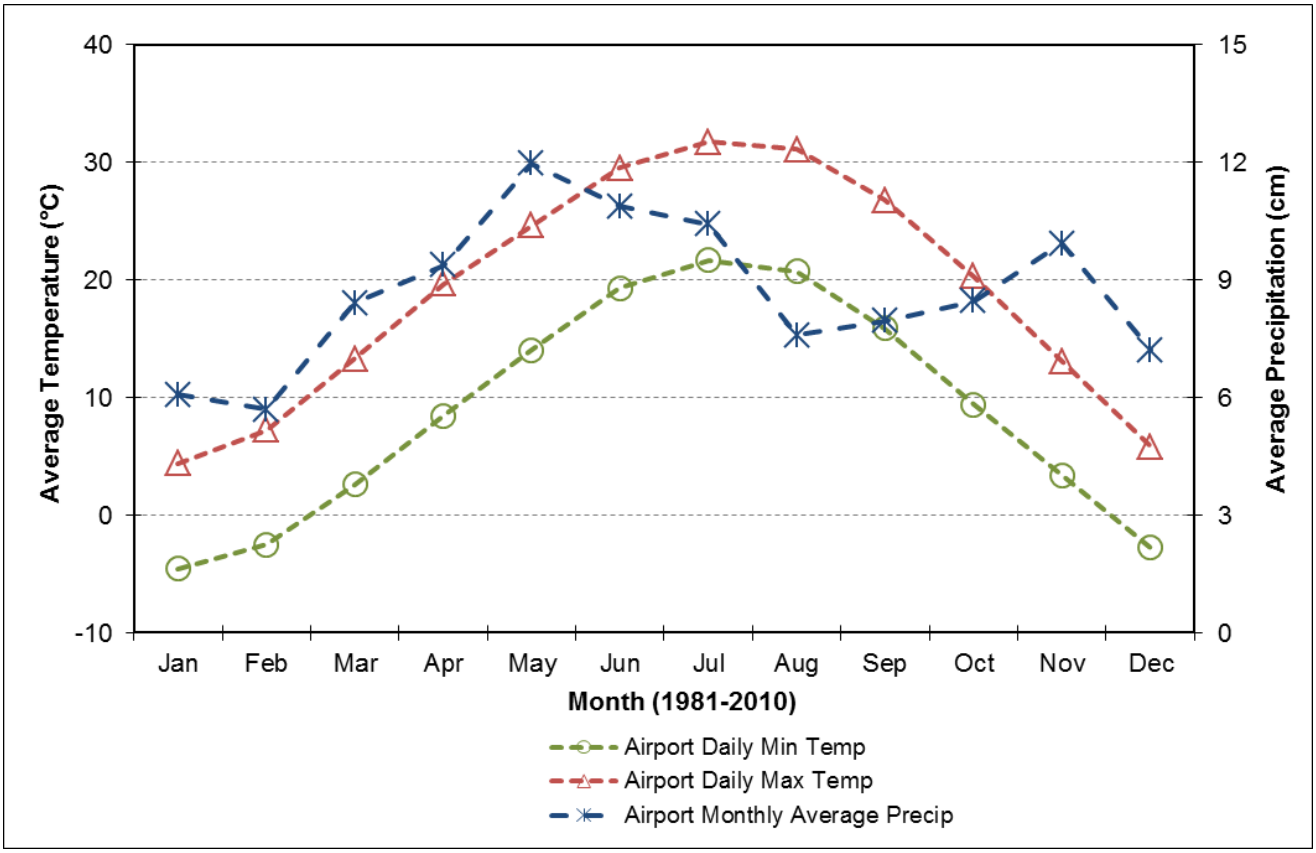

Figure 3. 30-year climate data from the St. Louis International Airport weather station (NOAA 2011)

2.3 Population

St. Louis County covers an area of 1,355 km^2 (523 mi^2) and, according to 2010 census data, has a population of 999,021 people (U.S. Census Bureau 2010). The population of the Maline Creek watershed is not directly available; however, using U.S. Census Bureau census block data from 2010, the population of the Maline Creek watershed is estimated to be approximately 84,295. This estimation was completed by using Geographic Information System, or GIS, software and superimposing the watershed boundary over a map of census blocks. Where the centroid of a census block fell within the watershed boundary, its total population was included in the total. If the centroid of the census block was outside the watershed boundary, then the population was excluded. This densely populated watershed is entirely contained within a U.S. Census Bureau defined urban area.[7] EPA defines urban areas as entities requiring stormwater regulations through municipal separate storm sewer permits (EPA 2014a).

EPA completed a separate population analysis for purposes unrelated to this TMDL. They used demographic and census block data and a web-based tool called EJSCREEN to determine areas of the state having potential Environmental Justice concerns. EPA defines Environmental Justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations and policies (EPA 2014b). Environmental Justice communities may qualify for financial and strategic assistance for addressing environmental and public health issues (EPA 2011a). From this analysis, EPA determined that the Maline Creek watershed has potential Environmental Justice concerns for approximately 50 to 70 percent of its area.

2.4 Land Cover

Land cover characterization was made using the 2011 National Land Cover Database published by the U.S. Geological Survey, or USGS (Homer et al. 2015). The land cover calculations are presented in Table 3 and a map showing the distribution of the various land coverages in the watershed is shown in Figure 4. As can be seen from this information, the watershed is approximately 95 percent developed. More than 54 percent of the watershed area is categorized as being low intensity development. Areas of low intensity development have 20 to 49 percent impervious cover and are composed primarily of single-family housing units. Areas of medium intensity development are also composed of single-family housing units, but contain from 50 to 79 percent impervious cover. Approximately 13 percent of the watershed area is in the medium intensity development category. Less than 6 percent of the watershed area is in areas of high intensity development where impervious cover is as high as 80 to 100 percent. According to the Metropolitan St. Louis Sewer District, actual imperviousness in the watershed is approximately 30 percent. This amount of imperviousness in the Maline Creek watershed is significant as stream degradation associated with imperviousness has been shown to first occur at about 10 percent imperviousness and to increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994).

[7] An urban area is delineated by the U.S. Census Bureau to represent densely populated areas (https://www.census.gov/geo/reference/ua/urban-rural-2010.html)

Areas of less imperviousness are also found in the watershed, but are still associated with some degree of development. Approximately 21 percent of the watershed area is developed open space, which is composed primarily of lawn grasses such as those found in parks, yards, and golf courses, or planted for erosion control and aesthetic purposes. Impervious surfaces in these areas are still common, but account for less than 20 percent of the cover. In addition to these less developed areas, pervious areas such as forest and shrub and herbaceous lands are present in the watershed, but make up less than 5 percent of the area's land cover. Other land cover types present in the Maline Creek watershed make up very minute portions of the watershed and are presented in Table 3.

Table 3. Land Cover in the Maline Creek watershed

Land Cover	***Area***		
	Hectares (acres)	***km^2 (mi^2)***	***Percentage***
Developed, High Intensity	376 (929)	3.76 (1.45)	5.69
Developed, Medium Intensity	859 (2,123)	8.59 (3.32)	13.00
Developed, Low Intensity	3,615 (8,934)	36.15 (13.96)	54.70
Developed, Open Space	1,425 (3,522)	14.25 (5.50)	21.56
Forest	273 (674)	2.73 (1.05)	4.13
Shrub and Herbaceous	4 (10)	0.04 (0.02)	0.06
Barren Land	32 (78)	0.32 (0.12)	0.48
Wetlands	25 (61)	0.25 (0.10)	0.38
Open Water	1 (2)	0.01 (0.00)	< 0.01
Total:	6,610 (16,333)	66.10 (25.52)	100.00

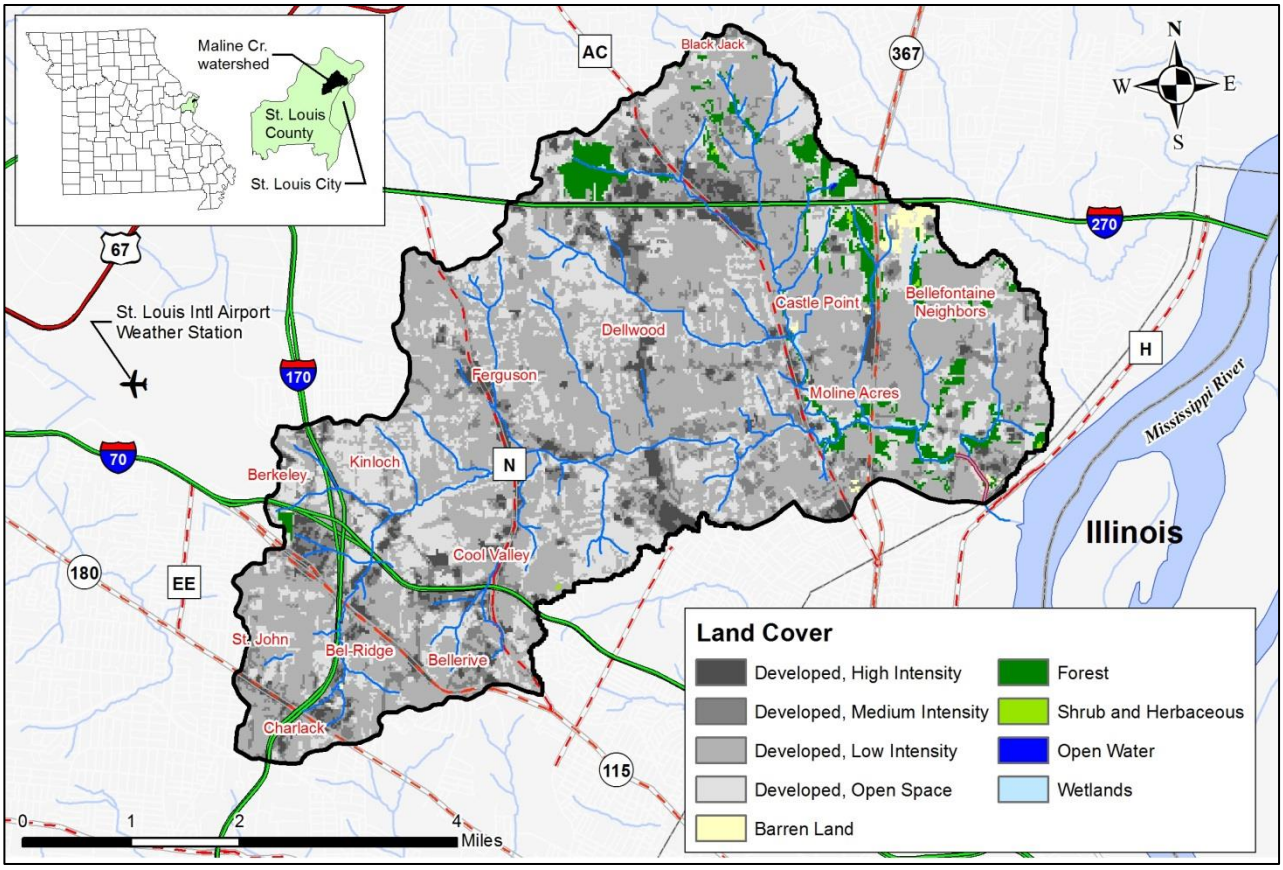

Figure 4. Land cover in the Maline Creek watershed

3. Applicable Water Quality Standards

The purpose of developing a TMDL is to identify the pollutant loading that a water body can assimilate and still attain water quality standards. Water quality standards are therefore central to the TMDL development process. Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters (U.S. Code Title 33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy.

3.1 Designated Uses

Designated uses are the uses for a water body defined in state water quality standards at 10 CSR 20-7.031(1)(C) and assigned per 10 CSR 20-7.031(2) and Table H.[8] These uses must be maintained in accordance with the federal Clean Water Act. The following designated uses have been assigned to Maline Creek and are reflected in the Missouri Use Designation Dataset as described in 10 CSR 20-7.031(2)(E):

- Livestock and wildlife protection
- Irrigation

[8] The terminology used for naming designated uses varies from what is presented in the text of 10 CSR 20-7.031 and what is presented in Table H. The terminology utilized in the text of the water quality standards rule is presented here.

- Protection and propagation of fish, shellfish and wildlife – warm water habitat
- Human health protection
- Secondary contact recreation
- Whole body contact recreation category B

The use impaired by bacteria is the protection of whole body contact recreation category B. Whole body contact recreation includes activities in which there is direct human contact with surface water that results in complete body submergence, thereby allowing accidental ingestion of the water as well as direct contact to sensitive body organs, such as the eyes, ears and nose. Category A waters include water bodies that have been established as public swimming areas and waters with documented existing whole body contact recreational uses by the public (10 CSR 20-7.031(1)(C)2.A.(I)). Category B applies to waters designated for whole body contact recreation, but are not contained within category A (10 CSR 20-7.031(1)(C)2.A.(II)).

3.2 Water Quality Criteria

Water quality criteria are limits on certain chemicals or conditions in a water body to protect particular designated uses. Water quality criteria can be expressed as specific numeric criteria or as general narrative statements.

In Missouri's Water Quality Standards at 10 CSR 20-7.031(5)(C) and Table A, specific numeric criteria are given for the protection of the whole body contact recreation use. For category B waters, *E. coli* counts, measured as a geometric mean, shall not exceed 206 counts/100 mL of water during the recreational season. The state's recreational season is defined in this section of the rule as being from April 1 to October 31.

3.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation, and may be found at 10 CSR 20-7.031(3).

Tier 1 – Protects existing uses and a level of water quality necessary to maintain and protect those uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after Nov. 28, 1975, the date of EPA's first Water Quality Standards Regulation.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological

significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goals for Maline Creek are to restore the stream's water quality to levels that meet water quality standards.

4. Defining the Problem

Missouri's Water Quality Standards use *E. coli*, bacteria found in the intestines of humans and warm-blooded animals, as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. The department judges a stream to be impaired if the water quality criteria are exceeded in any of the last three years for which there is a minimum of five samples collected during the recreational season. This approach is detailed in the department's 2016 Listing Methodology Document, which is available online at dnr.mo.gov/env/wpp/waterquality/303d/303d.htm.

Per federal regulations at 40 CFR§130.7(c)(1), a TMDL is needed for Maline Creek, because the department has determined that this stream is not meeting applicable water quality standards. Recreational season *E. coli* bacteria data collected from Maline Creek from 2010 – 2012 are summarized in Table 4. Individual bacteria measurements collected during this period are presented in Appendix A. Observed *E. coli* measurements are presented here for illustration purposes only and were not used in the calculation of the TMDL loading capacity or allocations.

Table 4. Recreational season *E. coli* data for the impaired segments of Maline Creek

Water Body ID #	***Year***	***Number of Samples***	***Minimum (count/100mL)***	***Maximum (count/100mL)***	***Geometric Mean (count/100mL)***
1709	2010	5	269	3,448	555
	2011	7	107	12,500	903
	2012	6	75	20,000	667

5. Source Inventory and Assessment

Source inventory and assessment characterizes known, suspected and potential sources of pollutant loading to a water body. Pollutant sources identified within the watershed are categorized and quantified to the extent that information is available. Sources of pollutants may be point (regulated) or nonpoint (unregulated) in nature

5.1 Point Sources

Point sources are defined under Section 502(14) of the federal Clean Water Act and are typically regulated through the Missouri State Operating Permit program.[9] Point sources include any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by

[9] The Missouri State Operating Permit system is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES) program. The NPDES program requires all point sources that discharge pollutants to waters of the United States to obtain a permit.

which pollutants are transported to a water body. Under this definition, permitted point sources include permitted municipal and non-municipal domestic wastewater dischargers, site-specific permitted industrial and non-domestic wastewater dischargers, and general and stormwater permitted entites, which include concentrated animal feeding operations, no-discharge domestic wastewater facilities, and stormwater discharges from municipal separate storm sewer systems. In addition to these permitted sources, illicit straight pipe discharges, which are illegal and therefore unpermitted, are also considered point sources.

At the time of this writing, the Maline Creek watershed received discharges from 40 permitted entities. Of these 40 permits, one is a site-specific permit for the discharge of stormwater from an industrial non-domestic facility, two are for municipal separate storm sewer systems, one is a general wastewater permit, and 36 are general stormwater permits. There are no permitted CAFO facilities in the Maline Creek watershed. In addition to these permitted sources, illicit straight pipe discharges, which are illegal and therefore unpermitted, are also considered point sources. Figure 5 shows the location of point source outfalls within the Maline Creek watershed.

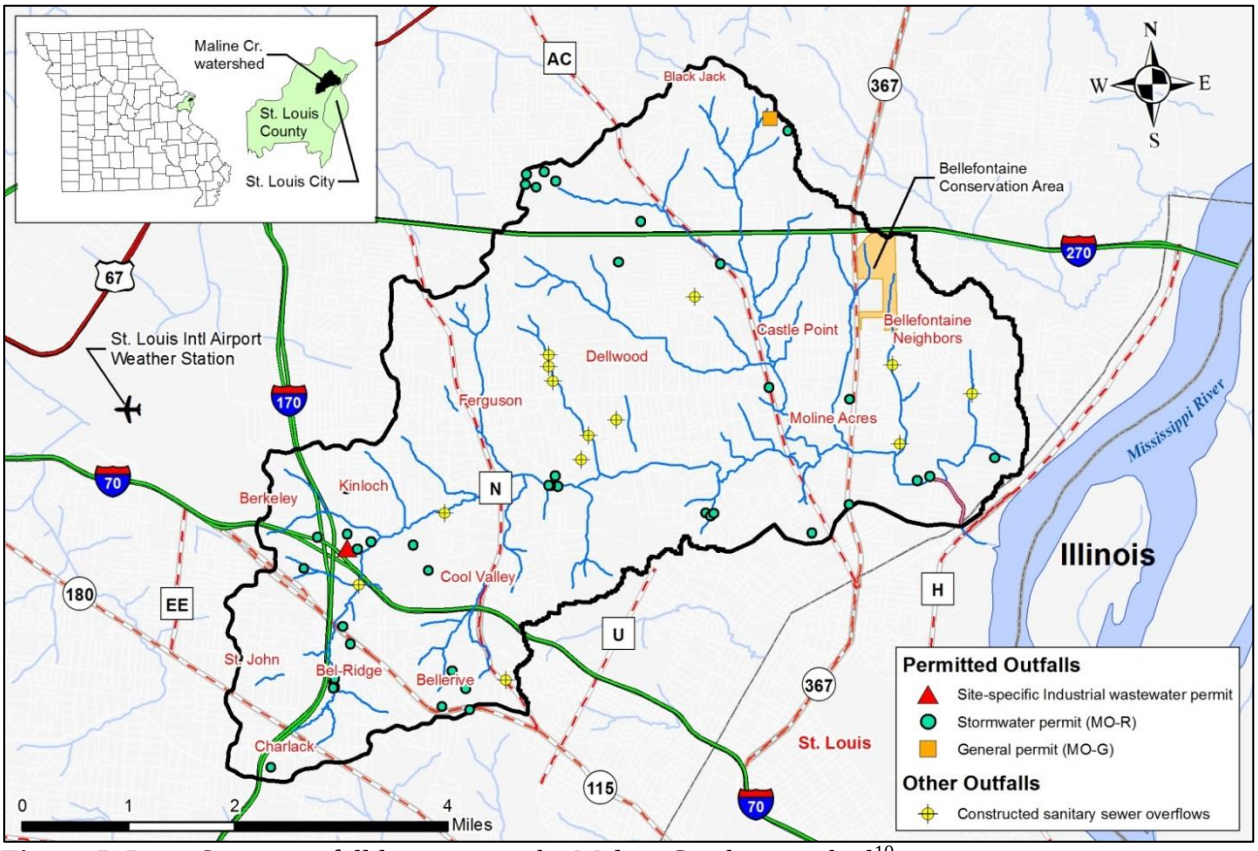

Figure 5. Point Source outfall locations in the Maline Creek watershed[10]

[10] Two MS4 permits regulate discharges of stormwater runoff throughout the entire watershed area. Permit no. MO-0137910 regulates stormwater discharges from Missouri Department of Transportation properties and right-of-ways and permit no. MO-R040005 regulates MS4 stormwater discharges from all other areas within the watershed.

5.1.1 Municipal and Non-Municipal Domestic Wastewater Permits

Domestic wastewater dischargers include both municipal and non-municipal wastewater treatment facilities. Domestic wastewater is primarily household waste, which includes graywater and sewage. Untreated or inadequately treated discharges of domestic wastewater can be significant sources of bacteria to receiving waters (EPA 1986). However, there are no municipal or other domestic wastewater permitted discharges in the Maline Creek watershed. The Metropolitan St. Louis Sewer District operates and maintains a sanitary sewer system in the watershed. The collected domestic wastewater is delivered to the Bissell Point wastewater treatment facility (permit MO-0025178) located outside of the watershed. The sewage collection and transport system infrastructure, within the Maline Creek watershed, is a potential source of bacteria due to possible breakage or overflows.

Sanitary sewer overflows are untreated or partially treated sewage releases from a sanitary sewer system. Overflows could occur for a variety of reasons including blockages, line breaks, sewer defects, power failures and vandalism. Sanitary sewer overflows can occur during either dry or wet weather and at any point in the collection system, including manholes. Such overflows are unauthorized by the federal Clean Water Act. Occurrences of sanitary sewer overflows can result in elevated bacteria concentrations (EPA 1996). During the period of January 2012 through December 2015, 22 sanitary sewer overflows in the Maline Creek watershed were reported to the department (Table 5). Sixteen of these overflows occurred during the recreational season; however, some overflows discharged to dry land or were otherwise contained and did not reach a water body in the Maline Creek watershed. Constructed sanitary sewer overflows, designed to relieve the sanitary sewer system during heavy rainstorms, are also present in the Maline Creek watershed (MSD 2015). According to the Metropolitan St. Louis Sewer District, there are 13 constructed sanitary sewer overflows in the Maline Creek watershed (Figure 5).

A USGS study about the sources of *E. coli* in metropolitan St. Louis area streams estimated that during the study, at least one-third of the measured in-stream *E. coli* in St. Louis area streams originated from humans.[11] The study also indicated that there is a correlation between *E. coli* densities and the number of upstream sanitary sewer overflows (USGS 2010). For these reasons, sanitary sewer overflows are considered potential contributors of *E. coli* to Maline Creek. For this TMDL report, constructed sanitary sewer overflows are considered the primary bacteria contributors to Maline Creek and initial TMDL implementation efforts should focus primarily on addressing these sources. After contributions from these sources are sufficiently minimized, existing loading should be reevaluated to determine the extent of implementation necessary to address other suspected sources described in this TMDL report. Implementation of actions required to address constructed sanitary sewer overflows should be conducted in accordance with the consent decree established as part of the *United States of America and the State of Missouri, and Missouri Coalition for the Environment Foundation v. Metropolitan St. Louis Sewer District*, No. 4:07-CV-1120.

[11] This USGS study categorized samples as either human, dog, or geese when 80 percent of the genetic markers were similar. Those with a less than 80 percent match were categorized as unknown. However, those categorized as unknown may include some percentage of human, dog or geese as well as other urban wildlife (USGS 2010).

Table 5. Reported sanitary sewer overflows in the Maline Creek watershed (2012 – 2015)

Date	***Weather Conditions***	***Cause***
March 14, 2012	Dry	Vandalism
March 14, 2012	Dry	Plugged sewer
May 2, 2012	Dry	Plugged sewer
May 28, 2012	Dry	Plugged sewer
June 15, 2012	Dry	Pipe break
Oct. 8, 2012	Dry	Plugged sewer
Dec. 14, 2012	Dry	Plugged sewer
April 21, 2013	Dry	Plugged sewer
April 25, 2013	Dry	Plugged sewer
May 26, 2013	Dry	Plugged sewer
Aug. 8, 2013	Dry	Pipe break
Aug. 19, 2013	Dry	Equipment malfunction
Sept. 5, 2013	Dry	Plugged sewer
March 22, 2014	Dry	Vandalism
March 22, 2014	Dry	Vandalism
April 27, 2014	Dry	Plugged sewer
June 23, 2014	Dry	Plugged sewer
Sept. 15, 2014	Dry	Broken sewer
Dec. 3, 2014	Dry	Plugged sewer
April 2, 2015	Dry	Pipe break
June 5, 2015	Dry	Plugged sewer
July 2, 2015	Dry	Broken sewer

Source: Missouri Department of Natural Resources – Water Protection Program

5.1.2 Site-Specific Industrial and Non-Domestic Wastewater Permits

Site-specific industrial and non-domestic wastewater permits differ from general wastewater permits by having conditions specific to a facility's site and operation. Industrial and non-domestic facilities discharge wastewater resulting from non-sewage generating activities and are typically not expected to cause or contribute to bacteria impairments. There is one site-specific non-domestic wastewater discharger in the Maline Creek watershed. Permit number MO-0111210 is issued to the Lambert-St. Louis International Airport and authorizes the discharge of stormwater. According to the fact sheet for this permit, the department was unable to identify any potential sources of bacteria from this facility. This facility is not considered to be a significant source of bacteria to Maline Creek.

5.1.3 Municipal Separate Storm Sewer System (MS4) Permits

There are two municipal separate storm sewer system permits, or MS4 permits, in the Maline Creek watershed. One is a site-specific permit issued to the Missouri Department of Transportation, permit number MO-0137910, and regulates stormwater discharges from highway right-of-ways and other MoDOT owned properties. This permit is more commonly referred to as a transportation separate storm sewer system permit, or TS4 permit. The second MS4 permit in the watershed,

permit number MO-R040005, is a general small MS4 permit issued to the Metropolitan St. Louis Sewer District and its co-permittees. Co-permittees in the Maline Creek watershed include St. Louis County and the municipalities of Bel-Nor, Bel-Ridge, Bellefontaine Neighbors, Berkeley, Black Jack, Calverton Park, Charlack, Cool Valley, Dellwood, Ferguson, Florissant, Hazelwood, Jennings, Moline Acres, Normandy, Overland, Riverview, and St. John.

MS4 permits authorize the discharge of urban stormwater runoff. In general, urban runoff carries high levels of bacteria and may result in exceedances of water quality criteria during and immediately after storm events in most streams throughout the country (EPA 1983). *E. coli* contaminated runoff can come from both heavily paved areas and from open areas where soil erosion is common (Burton and Pitt 2002). For these reasons, urban runoff is a potential contributor of bacteria to Maline Creek.

Bacterial loading to streams from urban runoff can be caused by sanitary sewer overflows as discussed in Section 5.1.1 of this document, but also commonly results from residential and green space runoff carrying domestic and wild animal waste. Birds, dogs, cats, and rodents have been documented as common sources of *E. coli* in urban stormwater (Burton and Pitt 2002). The USGS study specific to the sources of *E. coli* in metropolitan St. Louis streams discussed in Section 5.1.1 of this document estimated that in addition to one third of the bacteria originating from human sources, 10 percent of the sampled *E. coli* was attributed to dogs and 20 percent to geese (USGS 2010). Another component of urban stormwater is runoff originating from highway corridors. The Federal Highway Administration published research showing that runoff from highway corridors may also contain bacteria. Sources of *E. coli* within highway areas identified in the study include bird droppings, soil, and vehicles carrying livestock and stockyard wastes, which may periodically "seed" a roadway with pathogens. The study further notes that the magnitude and contributions from highway systems are site-specific and can be affected by numerous factors, such as traffic, design, maintenance, land use, climate and accidental spills (FHWA 1984). For these reasons, the significance of any highway contributions of bacteria in the Maline Creek watershed cannot be quantified in this TMDL report. Due to the intermittent and potentially sporadic nature of highway bacterial contributions described in the federal study, and due to the urban nature of the watershed, which makes contributions from the transport of livestock and stockyard wastes less likely, highway systems are not expected to be a significant contributor to the bacteria impairments in the Maline Creek watershed. Highway systems, however, do remain a potentially significant source of heavy metals, inorganic salts, aromatic hydrocarbons and suspended solids (FHWA 1998).

Stormwater discharges of urban runoff within the entire Maline Creek watershed are regulated through the before mentioned MS4 permits and for this reason urban runoff is considered a point source in this TMDL report. Although stormwater discharges are often untreated, MS4 permit holders must develop, implement, and enforce stormwater management plans to reduce the contamination of stormwater runoff and prohibit illicit discharges. These plans must include measurable goals, be reported on annually, and meet six minimum control measures. These six minimum control measures are public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention.

5.1.4 General Wastewater and Non-MS4 Stormwater Permits

General and stormwater permits are issued based on the type of activity occurring and are meant to be flexible enough to allow for ease and speed of issuance, while providing the required protection of water quality. General and stormwater permits are issued to activities similar enough to be covered by a single set of requirements, and are designated with permit numbers beginning with "MO-G" or "MO-R" respectively. A summary of the general and non-MS4 stormwater permits in the Maline Creek watershed, as of Dec. 27, 2016, is presented in Table 6. Permits associated with land disturbance activities are temporary and the number of effective permits of this type in the watershed may vary in any given year. Despite this variability, TMDL calculations and targets will not change as a result of any changes in the numbers of these types of permits.

The department assumes activities authorized under these general and stormwater permits will be conducted in compliance with all permit conditions, including monitoring and discharge limitations. It is expected that compliance with these permits will be protective of the designated recreational uses within the watershed. For these reasons, these facilities are not expected to cause or contribute to the bacterial impairment of Maline Creek. If at any time the department determines that the water quality of streams in the watershed is not being adequately protected, the department may require the owner or operator of the permitted site to obtain a site-specific operating permit, per 10 CSR 20-6.010(13)(C).

Table 6. General (MO-G) and non-MS4 stormwater (MO-R) permits

Permit No.	***Facility Name***	***Discharge Type***	***Permit Type***	***Permit Expires***[12]
MO-G760069	St. Louis Co. Parks-Veterans Memorial	Non-domestic	Swimming pool	7/31/2019
MO-R203464	PermaLok Corp. A Northwest Pipe Co.	Stormwater	Metal fabrication	8/31/2019
MO-R23A067	Jost Chemical Company Inc.	Stormwater	Chem. manufacturing	10/31/2020
MO-R60A150	Overland Metals, LLC	Stormwater	Vehicle salvage	10/31/2020
MO-R80C095	SDX	Stormwater	Motor freight	10/4/2017
MO-R80C481	UPS Cartage Services Inc.	Stormwater	Motor freight	10/4/2017
MO-R80C484	Special School District	Stormwater	Motor freight	10/4/2017
MO-R80C493	MV Student Transportation	Stormwater	Motor freight	10/4/2017
MO-R80H021	Metal Recovery Systems	Stormwater	Solid waste transfer	8/31/2019
MO-R80H024	Branch Metal Processing	Stormwater	Solid waste transfer	8/31/2019
MO-RA00872	Family Dollar	Stormwater	Land disturbance	2/7/2017
MO-RA01080	Fifth Third Bank	Stormwater	Land disturbance	2/7/2017
MO-RA01197	Believers Temple Word Fellowship	Stormwater	Land disturbance	2/7/2017
MO-RA01996	Springwood Apartments	Stormwater	Land disturbance	2/7/2017
MO-RA03104	Lions Park	Stormwater	Land disturbance	2/7/2017
MO-RA03150	Project Logan	Stormwater	Land disturbance	2/7/2017
MO-RA03716	North County Recreation Center	Stormwater	Land disturbance	2/7/2017
MO-RA04082	North County Technical High School	Stormwater	Land disturbance	2/7/2017

[12] If a permit has expired, then a facility remains bound by the conditions of that permit until either the permit is terminated or a new permit is issued.

MO-RA04312	UMSL Recreation and Wellness Center	Stormwater	Land disturbance	2/7/2017
MO-RA04385	Ackerman School	Stormwater	Land disturbance	2/7/2017
MO-RA04543	University of Missouri St. Louis (UMSL)	Stormwater	Land disturbance	2/7/2017
MO-RA04857	Northview High School	Stormwater	Land disturbance	2/7/2017
MO-RA04982	St. Louis County Library Lewis Clark	Stormwater	Land disturbance	2/7/2017
MO-RA05401	Pillar	Stormwater	Land disturbance	2/7/2017
MO-RA05482	QuikTrip #601S	Stormwater	Land disturbance	2/7/2017
MO-RA05737	Northpark Ph1 E of Hanley	Stormwater	Land disturbance	2/7/2017
MO-RA05948	UMSL New College of Business - Phase 1	Stormwater	Land disturbance	2/7/2017
MO-RA06285	Northpark Farmer Relocation	Stormwater	Land disturbance	2/7/2017
MO-RA06809	Devotional Baptist Church	Stormwater	Land disturbance	2/7/2017
MO-RA07179	Lafayette Industries - North Facility	Stormwater	Land disturbance	2/7/2017
MO-RA07321	Starbucks	Stormwater	Land disturbance	2/7/2017
MO-RA07494	UMSL New College of Business - Phase 1	Stormwater	Land disturbance	2/7/2017
MO-RA07558	Bel-Ridge Center	Stormwater	Land disturbance	2/7/2017
MO-RA07909	Residences at Jennings Place Phase II	Stormwater	Land disturbance	2/7/2017
MO-RA08136	Northpark Phase II W. of Hanley	Stormwater	Land disturbance	2/7/2017
MO-RA08740	Dunn Road Manor II	Stormwater	Land disturbance	2/7/2017
MO-RA08766	Lions Park	Stormwater	Land disturbance	2/7/2017

5.1.5 Illicit Straight Pipe Discharges

Illicit straight pipe discharges of domestic wastewater are also potential point sources of bacteria. These types of sewage discharges bypass treatment systems, such as a septic tank or a sanitary sewer, and instead discharge directly to a stream or an adjacent land area (Brown et al. 2004). Illicit straight pipe discharges are illegal and are not authorized under the Clean Water Act. At present, there are no data about the presence or number of illicit straight pipe discharges in the Maline Creek watershed. As noted in Section 5.1.3, illicit discharge detection and elimination is one of the six minimum control measures required by an MS4 permit. Such sources are therefore expected to be detected and eliminated in accordance with permitted conditions.

5.2 Nonpoint Sources

Nonpoint source pollution refers to pollution coming from diffuse, non-permitted sources that typically cannot be identified as entering a water body at a single location. They include all other categories of pollution not classified as being from a point source, and are exempt from department permit regulations as per state rules at 10 CSR 20-6.010(1)(B)1. These sources involve stormwater runoff and are minor or negligible under low-flow conditions. Typical nonpoint sources of pollution that have the potential to influence water quality include various sources associated with runoff from agricultural and non-MS4 permitted urban areas, onsite wastewater treatment systems, and riparian corridor conditions.

5.2.1 Agricultural Runoff

Stormwater runoff from lands used for agricultural purposes is often a source of bacterial loading to water bodies. Activities associated with agricultural land uses that may contribute bacteria to a

water body include manure fertilization of croplands or pastures, and livestock grazing. However, as noted in Section 2.4, no agricultural land coverages were identified in the Maline Creek watershed.

5.2.2 Urban Runoff (non-MS4 permitted areas)

Stormwater runoff from municipalities not required to have an MS4 permit is considered a nonpoint source. In the Maline Creek watershed, stormwater runoff falls within the jurisdiction of two MS4 permits. Therefore, for purposes of this TMDL report, urban runoff within the Maline Creek watershed is considered a potential point source contributor of *E. coli.* For this reason, no nonpoint urban runoff sources have been identified that are likely to be contributing to the bacteria impairment of Maline Creek. See Section 5.1.3 of this document for a more detailed discussion of potential urban runoff contributions and MS4 permitting.

5.2.3 Onsite Wastewater Treatment Systems

When properly designed and maintained, onsite wastewater treatment systems (e.g., home septic systems) should not contaminate surface waters; however, onsite wastewater treatment systems do fail for a variety of reasons. When these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration), there can be adverse effects to surface water quality (Horsley & Witten 1996). Failing onsite wastewater treatment systems are known to be sources of bacteria, which can reach nearby streams through both surface runoff and groundwater flows, thereby contributing bacteria loads under either wet or dry weather conditions. Onsite wastewater treatment systems may contribute bacteria to Maline Creek either directly or as a component of urban stormwater.

The exact number of onsite wastewater treatment systems in the Maline Creek watershed is unknown; however, such systems are known to exist in some areas of the county that were developed prior to the sewerage systems serviced by the Metropolitan St. Louis Sewer District (Jack Fischer, St. Louis County Public Works, personal communication, June 6, 2011). Since the district maintains parcel and billing information, an estimate of the number of parcels in the watershed without a sewer connection and potentially having an onsite system can be made. From information provided by the Metropolitan St. Louis Sewer District, it is estimated that there are approximately 284 parcels in the Maline Creek watershed that have neither a sewer connection nor a water connection.

As stated in Section 5.1.1 of this document, the Maline Creek watershed is serviced by the Bissell Point wastewater treatment facility. Due to the availability of this sewer system and a St. Louis County ordinance requiring that a sewer connection to a building be made when a sanitary sewer line is within 200 feet of the property, many onsite wastewater treatment system eliminations have been made. The Metropolitan St. Louis Sewer District consent decree also required the implementation of a supplemental environmental project, which included decommissioning some septic tanks to low-income residents within the Metropolitan St. Louis Sewer District's service area. This supplemental project has been completed and any septic tank removals or repairs resulting from it will likely aid in reducing bacteria loads to Maline Creek.[13]

[13] Any references to implementation of a supplemental environmental project shall include the following reference: "This project was undertaken in connection with the settlement of an enforcement action, *United States of America and the State of Missouri, and*

A study conducted by the Electric Power Research Institute suggests that up to 50 percent of onsite wastewater treatment systems in Missouri may be failing (EPRI 2000). Despite the lack of specific data showing that onsite wastewater treatment systems are a significant problem in the Maline Creek watershed, the available failure rate data suggests that onsite wastewater treatment systems in the watershed are potential contributors of bacteria to Maline Creek either directly or as a component of MS4 stormwater. However, due to the overall urban nature of the watershed the number of onsite wastewater treatment systems present in the watershed is expected to be low.

5.2.4 Riparian Corridor Conditions

Riparian corridor conditions can have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of pollutants from runoff. Therefore, a stream with good riparian cover is better able to moderate the impacts of high pollutant loads than a stream with poor or no riparian cover. Table 7 presents land cover calculations for the riparian corridors within the Maline Creek watershed.

For this analysis, the same land cover data calculated in Section 2.4 of this document was used and the riparian corridor was defined as including a 30-meter area on each side of all the streams in the watershed that are included in the 1:24,000-scale National Hydrography Dataset.[14] As is the case with the watershed as a whole, the dominant land cover types in the riparian corridor are those associated with varying degrees of development and imperviousness. More than 58 percent of the riparian corridor in the Maline Creek watershed is categorized as having low to high intensity development and greater than 20 percent impervious coverage. Open space development, which contains less than 20 percent impervious cover, makes up approximately 30 percent of the riparian corridor. In total, developed land cover types account for approximately 88 percent of the total coverage in the riparian corridor. Runoff from these areas that has come in contact with pet or wildlife wastes or from which sanitary sewer overflows have occurred can contribute bacteria loads to the MS4 or directly to an adjacent water body. For these reasons, the riparian corridor condition within the watershed is a potential contributing source of bacteria to Maline Creek. For purposes of this TMDL report, bacterial contributions from riparian areas are incorporated into the MS4 wasteload allocation.

Missouri Coalition for the Environment Foundation v. Metropolitan St. Louis Sewer District, No. 4:07-CV-1120-CEJ, taken on behalf of the U.S. Environmental Protection Agency, State, and the Coalition under the Clean Water Act" (John R. Lodderhose, Metropolitan St. Louis Sewer District, email communication, Oct. 24, 2012).

[14] The National Hydrography Dataset is digital surface water data for geographic information systems (GIS) for use in general mapping and in the analysis of surface-water systems. Available URL: http://nhd.usgs.gov

Table 7. Land cover in the riparian areas of the Maline Creek watershed

Land Cover	***Area hectares (acres)***	***Area Km^2 (mi^2)***	***Percent (%)***
Developed, High Intensity	36 (91)	0.36 (0.14)	7.03
Developed, Medium Intensity	62 (151)	0.62 (0.24)	11.64
Developed, Low Intensity	209 (517)	2.09 (0.81)	39.78
Developed, Open Space	155 (385)	1.55 (0.60)	29.63
Barren Land	2 (7)	0.02 (0.01)	0.56
Forest	44 (109)	0.44 (0.17)	8.36
Wetlands	15 (37)	0.15 (0.06)	2.86
Open Water	1 (2)	0.01 (0.00)	0.14
Total:	524 (1,299)	5.24 (2.03)	100.00

6. Numeric TMDL Target and Modeling Approach

As noted in Section 3.2 of this document, Missouri's Water Quality Standards include specific numeric *E. coli* water quality criteria for waters designated for whole body contact recreation category B. This *E. coli* concentrations of 206 counts/100mL will serve as the numeric target for TMDL development for Maline Creek. This targeted concentrations will be expressed as daily loads that vary by flow using a load duration curve. Achieving the targeted loads will result in attainment of the whole body contact recreation category B use. Because the whole body contact recreation category B criterion is a geometric mean, fluctuations in instantaneous bacteria concentrations are expected and individual bacteria measurements greater than the TMDL target do not in and of themselves indicate a violation of water quality standards.

The load duration curve approach identifies the maximum allowable daily pollutant load for any given day as a function of the flow occurring that day, which is consistent with the Anacostia Ruling (*Friends of the Earth, Inc., et al v. EPA*, No 05-5010, April 25, 2006) and EPA guidance in response to this ruling (EPA 2006; EPA 2007a). EPA guidance recommends that all TMDLs and associated pollutant allocations be expressed in terms of daily time increments, and suggests that there is flexibility in how these daily increments may be expressed. EPA guidance indicates that where pollutant loads or water body flows are highly dynamic, it may be appropriate to use a load duration curve approach, provided that such an approach "identifies the allowable daily pollutant load for any given day as a function of the flow occurring on that day." In addition, for targets that are expressed as a concentration of a pollutant, it may be appropriate to use a table or graph to express individual daily loads over a range of flows as a product of a water quality criterion, stream flow and a conversion factor (EPA 2006).

The load duration curve is also useful in identifying and differentiating between storm-driven and steady-input sources. The load duration curve approach may be used to provide a visual representation of stream flow conditions under which pollutant criteria exceedances have occurred. Additionally, the approach may be used to assess critical conditions and to estimate the level of pollutant load reduction necessary to meet the surface water quality targets for bacteria in a stream (Cleland 2002; Cleland 2003).

To develop the load duration curve, average daily flow data collected from March 23, 2004 to Dec. 31, 2016, from the USGS gaging station 07005000 at Bellefontaine Neighbors was used. Flow data from this gage were adjusted based on the ratio of the watershed area to the gage drainage area. A detailed discussion of the methods and calculations used to develop the bacteria load duration curve in this TMDL report is presented in Appendix B.

7. Calculating Loading Capacity

A TMDL calculates the loading capacity of a water body and allocates that load among the various pollutant sources in the watershed. The loading capacity is the maximum pollutant load that a water body can assimilate and still attain water quality standards. It is equal to the sum of the wasteload allocation, load allocation and the margin of safety:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

Where LC is the loading capacity, ∑WLA is the sum of the wasteload allocations, ∑LA is the sum of the load allocations, and MOS is the margin of safety.

According to 40 CFR §130.2(i), TMDLs can be expressed in terms of mass per time, toxicity or other appropriate measures. For Maline Creek, the TMDL is expressed as *E. coli* counts per day using a load duration curve. To develop a load duration curve, the numeric TMDL target is multiplied by flow to generate the maximum allowable load at different flows.[15] Figures 6 presents the *E. coli* TMDL load duration curve calculated for Maline Creek. The y-axis describes bacteria loading as counts per day and the x-axis represents the frequency for which a particular flow is met or exceeded. The load duration curve presented in Figure 6 represents the loading capacity as a solid curve over the range of flows. Observed loads measured from the stream during the recreational season are plotted as points. The flow condition ranges presented (e.g., low flows) illustrate general base flow and surface-runoff conditions that are consistent with EPA guidance about using load duration curves for TMDL development (EPA 2007b). Table 8 presents selected TMDL loading capacities and TMDL allocations, representing each flow condition along the load duration curve.[16] The stated wasteload allocations are applicable throughout the watershed and will result in reduced bacteria loading and attainment of water quality standards in all streams in the Maline Creek watershed.

[15] $Load\left(\frac{\text{count}}{\text{time}}\right) = Concentration\left(\frac{\text{count}}{\text{volume}}\right) * Flow\left(\frac{\text{volume}}{\text{time}}\right)$

[16] Due to the extremely large numbers associated with bacteria loads, *E. coli* values are presented using scientific notation.

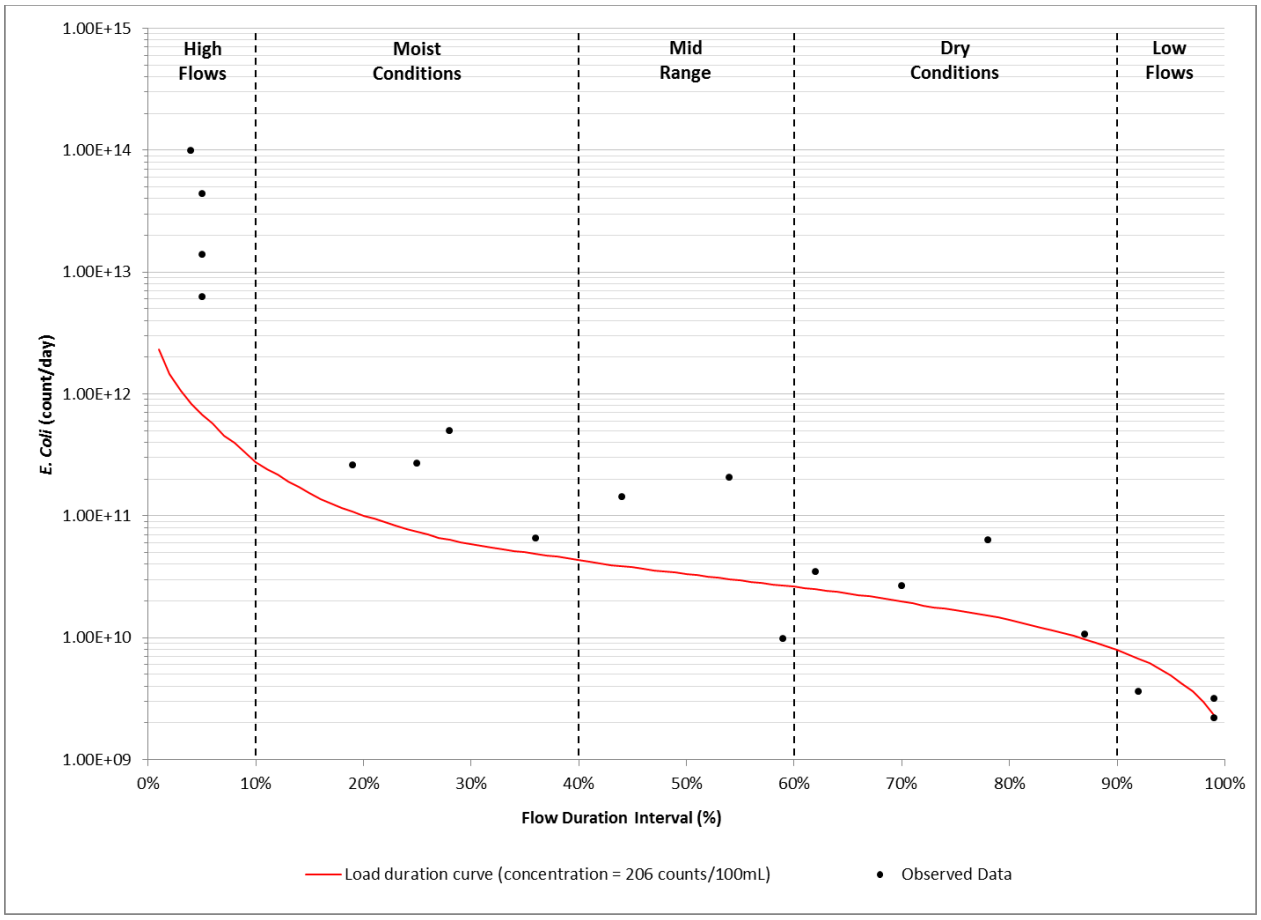

Figure 6. Maline Creek, WBID 1709, load duration curve

Table 8. Selected *E. coli* TMDL values for Maline Creek, WBID 1709

Percent of time flow exceeded	***Flow m^3/s (ft^3/s)***	***TMDL (count/day)***	***MS4 WLA (count/day)***	***LA (count/day)***
95	0.03 (0.97)	4.90E+09	4.90E+09	0
75	0.09 (3.33)	1.68E+10	1.68E+10	0
50	0.19 (6.58)	3.32E+10	3.32E+10	0
25	0.41 (14.63)	7.37E+10	7.37E+10	0
10	1.56 (54.93)	2.77E+11	2.77E+11	0

8. Wasteload Allocation (Point Source Load)

The wasteload allocation is the allowable amount of the loading capacity that is assigned to existing or future point sources. Typically, point sources are permitted with limits for a given pollutant that are the most stringent of either technology-based effluent limits or water quality-based effluent limits. Technology-based effluent limits are based upon the expected capability of a treatment method to reduce the pollutant to a certain concentration. Water quality-based effluent limits represent the most stringent concentration of a pollutant that a receiving stream can assimilate without violating applicable water quality standards at a specific location. Total wasteload allocations for Maline Creek are presented in Table 8.

8.1 Municipal and Domestic Wastewater Discharges

As noted in Section 5.1.1, domestic wastewater in the Maline Creek watershed is transferred through a sewerage system to a treatment works facility located outside of the watershed. Even so, sanitary sewer overflows still occur and are likely contributors of bacteria to Maline Creek and its tributaries. These discharges are not authorized under the Clean Water Act. For this reason, constructed sanitary sewer overflows in the Maline Creek watershed are given a wasteload allocation of zero. Elimination of bacteria loading from these sources will be accomplished through the requirements of the Metropolitan St. Louis Sewer District's consent decree.

8.2 Site-Specific Permitted Industrial and Non-Domestic Wastewater Facilities

Site-specific permitted industrial and non-domestic wastewater facilities are not sources of the impairments to Maline Creek and bacteria contributions from these facilities are not expected to significantly contribute to existing bacteria loads. For these reasons, site-specific permitted industrial and non-domestic wastewater facilities are not assigned a portion of the calculated wasteload allocation. Current permit conditions that result in bacteria loading at or below these *de minimis* levels should be maintained.

8.3 Municipal Separate Storm Sewer System (MS4) Permits

Wasteload allocations for MS4 discharges are presented in Table 8. In the Maline Creek watershed, stormwater runoff discharged through MS4s is regulated through two MS4 permits. Permit number MO-0137910 regulates MS4 discharges from Missouri Department of Transportation right-of-ways and permit number MO-R040005 regulates MS4 discharges from all other areas of the watershed. Bacterial contributions from MS4 permitted entities are precipitation dependent and vary with flow. For this reason, wasteload allocations to the MS4s will also vary with flow. Because stormwater discharges throughout the entire watershed are regulated through MS4 permits, and there are no other permitted facilities found to significantly contribute bacteria loads to Maline Creek, the entire wasteload allocation is allocated to the MS4s. An aggregated wasteload allocation is used, because the significance of any highway contributions of bacteria in the watershed cannot be quantified and bacteria loading from highway areas is assumed to be infrequent and minor. Future bacteria monitoring may provide more specific information regarding each MS4 area's actual contributions, including specific sources and mechanisms of transport, thereby allowing permit conditions to be modified accordingly.

8.4 General Wastewater and Non-MS4 Stormwater Permits

Table 6 lists facilities with general wastewater and non-MS4 stormwater permits. For purposes of this TMDL, the department assumes that activities from these facilities in the watershed will be conducted in compliance with all permit conditions, including monitoring and discharge limitations and that compliance with these permits will result in bacterial loading at or below applicable targets. Because these facilities are not considered to be sources of bacteria loading to the impaired segments of Maline Creek, these facilities are not assigned a portion of the wasteload allocation and current permit conditions that would result in bacteria loading at or below current *de minimis* levels should be maintained.

8.5 Illicit Straight Pipe Discharges

Illicit straight pipe discharges are illegal and are not permitted under the Clean Water Act. For this reason, illicit straight pipe discharges are assigned a wasteload allocation of zero and any existing sources of this type must be eliminated. In areas of the watershed where stormwater is regulated by MS4 permits, the detection and elimination of illicit discharges is a required permit condition.

8.6 Considerations for Future Sources

For this TMDL, no specific portion of the loading capacity is allocated to a reserve capacity. Due to the urban nature of the watershed and the presence of sewerage systems throughout, the likelihood of needing to reserve a portion of the total loading capacity for new facilities that have a significant potential to contribute bacteria loads to Maline Creek is low. Even so, the wasteload allocations presented in this TMDL report do not preclude the establishment of future point sources of bacteria in the watershed. Any future point sources should be evaluated against the TMDL and the range of flows, which any additional bacterial loading will affect, as well as any additional requirements associated with anti-degradation. Per federal regulations at 40 CFR 122.4(a), no permit may be issued when the conditions of the permit do not provide for compliance with the applicable requirements of the Clean Water Act, or regulations promulgated under the Clean Water Act. Additionally, 40 CFR 122.4(i) states no permit may be issued to a new source or new discharger if the discharge from its construction or operation will cause or contribute to violation of water quality standards. Future general (MO-G) and non-MS4 stormwater (MO-R) permitted activities that do not actively generate bacteria and that operate in full compliance with permit conditions are not expected to contribute bacteria loads above *de minimis* levels and will not result in loading that exceeds the sum of the TMDLs' wasteload allocations.

9. Load Allocation (Nonpoint Source Load)

The load allocation is the allowable amount of the pollutant load that can be assigned to nonpoint sources and includes all existing and future nonpoint sources, as well as natural background contributions (40 CFR §130.2(g)). Nonpoint sources identified to be potential contributors of bacteria include onsite wastewater treatment systems. If functioning properly, these systems should not be contributing to the impaired condition of Maline Creek. Onsite wastewater treatment systems are assigned a load allocation of zero. Other nonpoint sources are considered minimal for the purposes of this TMDL and therefore no load allocations are assigned for these sources.

10. Margin of Safety

A margin of safety is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. The margin of safety is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety as part of the critical conditions for the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

The margin of safety for these TMDLs is implicit due to conservative assumptions in the modeling of this TMDL, the use of multiple years of flow gage data collected under all flow conditions to create a robust TMDL calculation, and the reduced uncertainty of the sources of impairment and their remediation through the Metropolitan St. Louis Sewer District's consent decree. Additionally, bacteria decay rates were not applied and the direct recreation-season geometric mean was used for estimating the Clean Water Act required daily loading values.

11. Seasonal Variation

Missouri's water quality criteria for the protection of whole body contact recreation are applicable during the recreational season defined as being from April 1 to October 31. The TMDL load duration curve in Figure 6 represents stream flow under all conditions and uses flow data collected in all seasons. For this reason, the *E. coli* targets and allocations established in this TMDL will be protective throughout the recreational season and during flow conditions associated with storm-driven events, including those associated with seasonal rain patterns, when bacteria loading is more likely. The advantage of a load duration curve approach is that all flow conditions are considered and the constraints associated with using a single-flow critical condition are avoided.

12. Monitoring Plans

The department has not yet scheduled post-TMDL monitoring for Maline Creek. Post-TMDL monitoring is usually scheduled and carried out by the department approximately three years after the approval of the TMDL or in a reasonable period following completion of permit compliance schedules and the application of new effluent limits, or following significant implementation

activities such as removal of constructed sanitary sewer overflows. The department will routinely examine water quality data collected by other local, state and federal entities in order to assess the effectiveness of TMDL implementation. Such entities may include the USGS, EPA, the Missouri Department of Health and Senior Services, the Missouri Department of Conservation, county health departments and the Metropolitan St. Louis Sewer District. In addition, certain quality-assured data collected by universities, municipalities, private companies and volunteer groups may potentially be considered for monitoring water quality following TMDL implementation.

13. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is derived from the National Pollutant Discharge Elimination System, or NPDES. The wasteload allocation for MS4s will be implemented through the NPDES MS4 permits with the ultimate goal to employ an iterative process using best management practices (BMPs) to the maximum extent practicable (MEP), assessment, and refocused BMPs to the MEP, leading toward attainment of water quality standards (64 FR 68753).

The consent decree established as part of the *United States of America and the State of Missouri, and Missouri Coalition for the Environment Foundation v. Metropolitan St. Louis Sewer District*, No. 4:07-CV-1120 requires specific eliminations and reductions of point sources in the Metropolitan St. Louis Sewer District's service area. This court-approved decree will provide an additional reasonable assurance of bacteria reductions in Maline Creek from point sources over a 23-year period (EPA 2011b).

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. This generally occurs when the TMDL's combined nonpoint source load allocations and point source wasteload allocations do not exceed the water quality standards-based loading capacity and there is reasonable assurance that the TMDL's allocations can be achieved. Reasonable assurance that nonpoint sources will meet their allocated amount in the TMDL is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls or BMPs within the watershed. If BMPs or other nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed and approved for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. When a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls or BMPs are not feasible, durable, or will not result in the required load reductions, allocation of greater pollutant loading to point sources cannot occur.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed plans, controls and practices to meet the required wasteload and load allocations in the TMDL and demonstrate additional reasonable assurance.

14. Public Participation

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). The water quality-limited segments of Maline Creek in St. Louis County and city are included on Missouri's EPA-approved 2016 303(d) List of impaired waters. A 60-day public notice and comment period for this TMDL report was scheduled from March 3, 2017 through May 2, 2017. Comments received and the department's responses to those comments are to be maintained on file with the department and on the Maline Creek TMDL record webpage at dnr.mo.gov/env/wpp/tmdl/1709-3839-maline-cr-record.htm.

In addition to the public notification period previously described, the department also considered comments received during the public comment periods of four other *E. coli* TMDLs written for St. Louis area streams and submitted to EPA on January 7, 2015. These comment periods were held for 45 days each in 2012 and a combined 150 days in 2014. Additionally, comments provided by the Metropolitan St. Louis Sewer District in meetings with the department on July 22, 2014, Oct. 2, 2014, and Dec. 30, 2014 were also considered in the drafting of this TMDL.

Groups that directly received the public notice announcement for this TMDL include, but are not limited to:

- Missouri Clean Water Commission
- Missouri Water Protection Forum
- Missouri Department of Conservation
- Missouri Department of Transportation
- St. Louis County Soil and Water Conservation District
- Metropolitan St. Louis Sewer District
- St. Louis County Department of Health
- St. Louis County Council
- University of Missouri Extension
- Missouri Coalition for the Environment
- Stream Team volunteers living in or near the watershed
- Stream Teams United (formerly Missouri Stream Team Watershed Coalition)
- East-West Gateway Council of Governments
- Affected permitted entities
- Missouri state legislators representing areas within the watershed

Additionally, the public notice announcement, the TMDL Information Sheet, and this TMDL document have been posted on the department's TMDL webpage at dnr.mo.gov/env/wpp/tmdl/wpc-tmdl-progress.htm, making them available to anyone with Internet access.

The department also maintains an email distribution list for notifying subscribers regarding significant TMDL updates or activities, including public notices and comment periods. Those

interested in subscribing to these TMDL updates may do so by submitting their email address at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

15. Administrative Record and Supporting Documentation

An administrative record for the Maline Creek TMDL has been assembled and is being kept on file with the department. It includes any studies, data and calculations on which the TMDL is based. This information is available upon request to the department at dnr.mo.gov/sunshine-form.htm. Any request for information about this TMDL will be processed in accordance with Missouri's Sunshine Law (Chapter 610, RSMO) and the department's administrative policies and procedures governing Sunshine Law requests. For more information about open record/Sunshine requests, please consult the department's website at dnr.mo.gov/sunshinerequests.htm.

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Appendix A

Maline Creek *E. coli* data (2010 – 2014)

WBID	*Site Code*	*Site Description*	*Date*	*E. coli (#/100ml)*	*Flow m^3/s (ft^3/s)*
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	6/15/2010	3,448.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	7/13/2010	750.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	8/17/2010	272.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	9/14/2010	279.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	10/19/2010	269.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	4/12/2011	1,620.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	5/17/2011	754.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	6/14/2011	1,850.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	7/12/2011	496.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	8/17/2011	107.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	9/13/2011	327.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	10/18/2011	12,500.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	4/16/2012	20,000.0	193
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	5/21/2012	1,400.0	5.8
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	6/18/2012	830.0	3
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	7/16/2012	220.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	8/21/2012	230.0	
1709	1709/0.5	Maline Cr. at Bellefontaine Rd.	9/17/2012	75.0	

Appendix B

Development of bacteria load duration curves

B.1 Overview

The load duration curve approach was used to develop a TMDL for an impaired segment of Maline Creek. The load duration curve method allows for characterizing water quality concentrations (or water quality data) at different flow regimes and estimating the load allocations and wasteload allocations for each impaired segment. This method also provides a visual display of the relationship between stream flow and loading capacity. Using the duration curve framework, allowable loadings are easily presented.

B.2 Methodology

Using the load duration curve method requires a long time series of flow data, a numeric water quality target, and bacteria data from the impaired stream. Bacteria data from the impaired segments are converted into instantaneous loads using flow measurements for the same date and are plotted along with the load duration curve to illustrate conditions when the water quality targets may have been exceeded.

To develop a load duration curve, a long record of average daily flow data from a gage (or multiple gages) that is representative of the impaired reach is used. The flow record should be of sufficient length to be able to calculate percentiles of flow. If a flow record for an impaired stream is not available, then a synthetic flow record is needed. For the Maline Creek TMDL, flow records from March 23, 2004 to Dec. 31, 2016 collected by USGS stream gage 07005000 at Bellefontaine Neighbors were used. The modeling approach assumes that discharge at the outlet of the impaired watershed is proportional to the discharge from the USGS gage station. Therefore, average daily flow values were corrected based on the proportion of the area draining to the impaired watershed to that draining to the flow gage. The developed flow duration curve for the impaired water body segment is presented in Figures B1. These flows in units of ft^3/second are then multiplied by the applicable water quality target (206 counts/100 mL or 1,134 counts/100 mL) and a conversion factor of 24,465,715 in order to generate the allowable load in units of counts/day.[17] Despite the varying load, the targeted concentration is constant at all flow percentiles and reflects the static nature of the water quality standards.

Table B1. Drainage areas of gage and impaired watersheds and correction factors

Location:	USGS 07005000	WBID 1709
Drainage Area:	63.19 km^2 (24.4 mi^2)	66.04 km^2 (25.5 mi^2)
Correction Factor:	--	1.045

[17] $Load\ \left(\frac{\text{count}}{\text{day}}\right) = \left[Target\left(\frac{\text{count}}{\text{100ml}}\right)\right] * \left[Flow\ \left(\frac{feet^3}{s}\right)\right] * [Conversion\ Factor]$

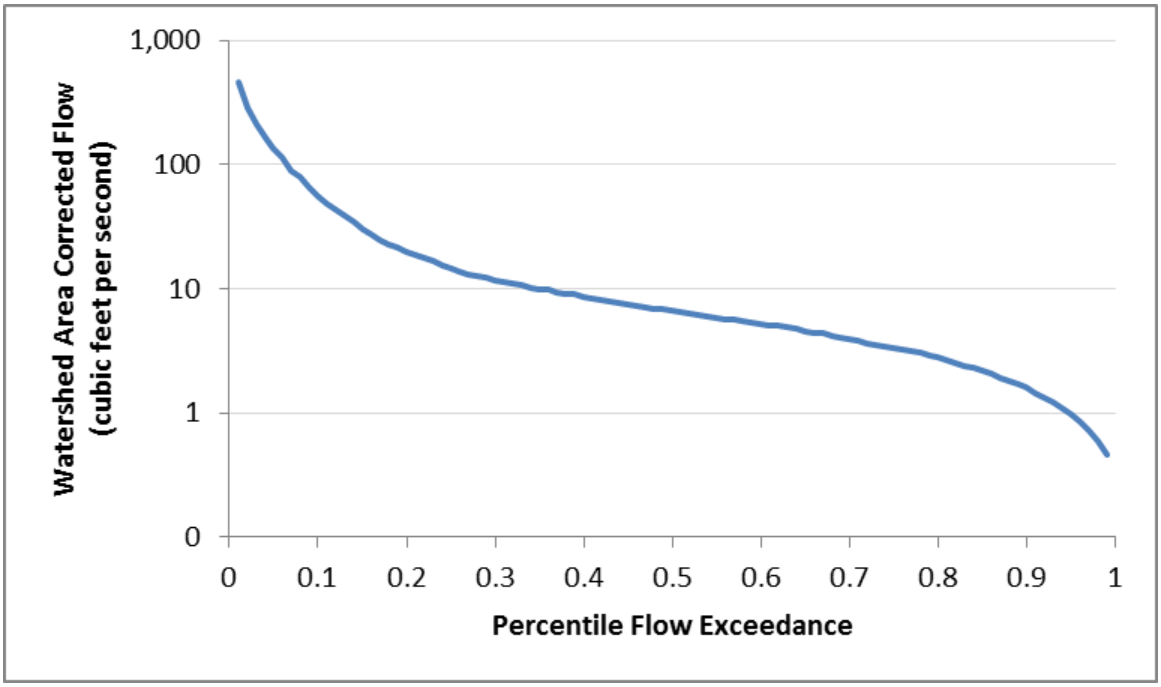

Figure B1 Flow duration curve for Maline Creek, WBID 1709